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CONTENTS

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COOPERATIVE RESEARCH: A CASE REPORT

COOPERATIVE scientific research among different major departments of different institutions is so rare and of such significance for the future development of American science that the story of the successful accomplishment of such an undertaking for now six years may prove to be stimulating as well as interesting. As a sequel to the growing complexity of scientific technique, it is probable that there will be an increase in the number of cooperative researches of the type to be described, since this form of scientific work possesses a distinct advantage in the pooling of knowledge and resources. Individual scientific achievement, of course, may always be expected to develop whenever genius and opportunity are in proper conjunction. As the specialties will continue to diverge, however, the organization of science will imply greater liaison and cooperation between the specialists, in order to advance the common front of scientific knowledge.

In the case to be described, the mutual incentive to productive effort has been so fruitful that a morale and enthusiasm has developed which is astonishing. Individual ambition has been disciplined to team work for the success of the endeavor as a whole, and instead of engendering the slight jealousies and friction which often arise between workers on the same scientific problem, friendships have been created and cemented which seem impossible of dissolution.

This particular cooperative venture originated with some of the scientists engaged in the Chemical Warfare Service during the war. Among those associated together at the American University Experiment Station at Washington were Professor A. S. Loevenhart, of the University of Wisconsin, and Professor W. Lee Lewis, of Northwestern University. Professor Lewis is the chemist who developed "Lewisite," about which so much romance arose at the end of the war, and Professor Loevenhart is the pharmacologist who directed the study of the action of this and other substances on the human body.

Professor Loevenhart became impressed with the significance of their cooperative researches. In discussing "an institute for research in synthetic organic chemistry" at a meeting in 1918, Professor Loevenhart said:

> In my work at the American University Experiment Station I have seen how satisfactory and effective research work in close cooperation between chemists and

pharmacologists may be. The object toward which we are working there is the development of materials destructive of life, but the thought naturally presents itself that if this cooperative work is so effective in war time for the development of offense weapons, in peace time such cooperation would be of enormous value in promoting the security of life and its comforts.

I may briefly recount the way in which the work at American University has been conducted. Most of the materials are produced by chemists working in the station. Formal conferences are held twice a week between pharmacologists and chemists, and there are informal conferences each day. At these conferences it is decided what substances should be prepared. When the materials are synthesized they are turned over to the pharmacological section for every sort of test. The results of these tests are then made known to the chemists and the possibilities of improving the materials are then discussed. I may say that the work has been eminently successful from every standpoint, and that the cooperation has been delightful. One can hardly realize until he has experienced it how the pharmacologist and chemist working together mutually stimulate one another.

I am therefore prepared to testify that cooperation of the kind proposed is not only practicable, but is the ideal condition for productive research. . . .

The need for an institution of the type proposed is obvious when one realizes that there is no institution in America to-day where the therapeutic value of a drug can be determined in a manner acceptable alike to scientific men and physicians. To my mind such an institute should not only foster the production and testing of remedial agents, but every phase of synthetic organic chemistry should be considered within its domain. This is necessary because remedial agents may be found among any group of organic chemical products.

Professor Loevenhart and Professor Lewis have partially realized this general scheme in the work to be described, in spite of the difficulties of operation with inadequate equipment and resources, and in spite of the great inconvenience of a wide geographical separation of the various phases of the work.

THE U. S. INTERDEPARTMENTAL SOCIAL HYGIENE BOARD

One of the minor consequences of the war was the creation in 1918 of the United States Interdepartmental Social Hygiene Board, which enlisted the forces of the War, Navy and Treasury Departments in a comprehensive campaign against venereal disease. The functions of the board included

> medical measures for the prevention, treatment and control of venereal diseases; protective measures primarily directed to the problem of safeguarding the Army and Navy; scientific research for the discovery of better medical methods for the prevention and treatment of venereal diseases; and educational measures for the discovery or development of better educational methods in the prevention of venereal diseases, or for psychological or sociological research related thereto.

The work of this board involved cooperative research on a grand scale, and however disorganized and unrelated the specific accomplishments of the various workers supported by grants from this board may seem, the results as a whole were magnificent.

During 1919, 1920 and 1921, the division of scientific research of the board distributed some $285,000 for some forty separate researches in twenty-three different institutions. Of this sum, $12,000 was given to Northwestern University to be administered for two purposes: (a) "A synthesis of organic compounds containing arsenic of possible value in the treatment of syphilis of the central nervous system," under the direction of Professor W. Lee Lewis, and (b) "a synthesis of new organic compounds of mercury for use in the treatment of syphilis of the central nervous system," directed by Professor Frank C. Whitmore. To the University of Wisconsin, $26,800 was given during the three years for the object of preparing and studying "mercurial and arsenical compounds which have a predilection for the central nervous system, in the hope of finding drugs more useful than any known in the treatment of syphilis of the central nervous system." It was the understanding between all parties concerned that whatever compounds were produced by the Northwestern group were to be submitted to the Wisconsin workers for biological study, and that the closest cooperation between the two groups was to be maintained. A total of twenty-three scientists and assistants engaged in this work at the two institutions during the three years it was supported by the grants from the U. S. Interdepartmental Social Hygiene Board.

Appropriations from the board were discontinued in 1921. In a recent report, it is stated that many of the research men operating under grants from the board indicated at that time that their studies were completed and that nothing could be gained by further appropriations. To quote from this report, it is said that this statement

> illustrates so admirably the honest spirit in which these investigations were conducted. But inasmuch as the best workers of the country were engaged in the work, it also suggests that a continuance of the fund, with the inevitable insistence of money—especially government money—to get itself spent, would have seen a deterioration in the product and a final degeneration of the whole mechanism into an official routine quite incompatible with free research. The scientific work of the Interdepartmental Board was conceived and executed in that spirit of ideal-

ism on the part of the government officials in charge which was calculated to meet the scientists on their own ground. That youthful idealism which the war inspired has gone, and gone with it is the probability of reproducing the circumstances necessary to the successful continuation of this work at the present time. The scientist, like the rest of us, must return to the humdrum of peace.

While these interesting observations may have been true of the general work of the board, thus justifying its demise, they were not at all true of the close cooperative work between Professors Lewis, Whitmore, Loevenhart and their associates at Northwestern and Wisconsin. Their effort was just beginning to get a good start when its support was withdrawn. The threatened collapse of their venture was averted by the financial help of a private organization which undertook to do in a large city what the Interdepartmental Board tried to do for the country as a whole.

THE PUBLIC HEALTH INSTITUTE OF CHICAGO

One of the medical officers in the army who had been impressed with the campaign against venereal disease started by the Interdepartmental Board was Dr. Joseph C. Berkowitz, of Chicago. Upon discharge from service, he conceived the idea of undertaking to handle the civil population of a large city with respect to venereal disease in somewhat the same manner which had been used with success in the army, and by using methods of advertising similar to those employed by the Public Health Service of the U. S. government. This idea involved treatment at a nominal cost.

The Public Health Institute was organized in February, 1920, by Dr. Berkowitz and Myron E. Adams, an experienced sociologist, with the support of many prominent men of Chicago, among whom were A. A. Sprague, Harold F. McCormick, T. R. Gowanlock, General J. A. Ryan, Samuel Insull, H. M. Byllesby, A. A. Carpenter and N. W. MacChesney. R. A. Gardner, J. M. Dickinson, Jr., N. B. Judah, Lester Armour and Marshall Field were later added to the trustees. These public-spirited citizens have taken a direct part in the management of the institute and have always decided its policies. This has assured to the institute the application of the best business intelligence available.

The immediate object was to provide adequate medical service for those sufferers from venereal diseases who belonged to the great middle class and who were therefore either too proud to avail themselves of free treatment at the dispensaries of medical schools or financially unable to afford the expense of proper examination and lengthy treatment at the hands of a qualified specialist. In order to make its presence known to the vast number of people who needed its services, it was necessary to advertise in the newspapers. These notices were carefully worded to emphasize the fact that the institute was organized for public service and not for profit. The names of the lay directors were published to guarantee this function.

Unfortunately, the Public Health Institute incurred the antagonism of a small group of Chicago physicians, who, vehement in their disapproval, took opportunity to attack the institute on the convenient grounds that it violated medical ethics by its advertising. Their expressed objections do not seem to have been well advised, but they served as a cloak to reality and as a placebo to conscience. It appears to be only a question of time when the leaders in the medical profession will discountenance such criticism on the part of their less magnanimous associates.

This digression may seem uncalled for, but it is introduced to illustrate the non-technical troubles which may arise in the progress of cooperative research. The problem of financing such a large undertaking brings contact with many different types of people. In order that the necessary harmony may prevail, it is essential for those engaged in the venture to understand each other, and to have full confidence in one another. Only under these conditions may possible antagonism be met with equanimity.

Venereal disease affects not only the present generation, but also innocent members of generations to come. Its treatment, therefore, becomes essentially a matter of public health. If this service can be rendered by a private institute, it relieves the state of assuming the burden. It is the ideal of the Public Health Institute of Chicago to make high-grade medical service of this character accessible to the mass of the people from the standpoints of time, place and money; in other words, to make it cheaper for a person to be cured than to remain ill of venereal disease. Even with the nominal charge which is made for this service, a surplus has accumulated. Since the institute is a non-profit organization, this can only be disposed of in an effort to improve its service to its clientele, in educational measures or in promoting research.

When the U. S. Interdepartmental Social Hygiene Board failed to continue the necessary funds for the continuation of the cooperative research at Northwestern and Wisconsin, the Public Health Institute came forward and granted the money each year to the present time. This support of scientific research in a field bearing upon its own problems was made an integral part of the program of the institute, and will continue to be so. Patronage of this sort is of national significance.

The cooperative effort between Professor Lewis and Professor Loevenhart and their associates has been, therefore, an uninterrupted affair since 1919, and it has produced important results. Before describing these, it may be of interest briefly to discuss the organization under which the research has operated.

ORGANIZATION

The research involves three major phases: (a) the chemical, (b) the pharmacological and (c) the clinical. The actual work in the first two phases is done by graduate students who are studying upon what is essentially a fellowship basis for their doctorates, while the clinical studies are handled by thoroughly trained and properly qualified physicians. The production of organic arsenical substances is under the direction of Professor W. Lee Lewis, and the synthesis of organic mercurial compounds is guided by Professor Frank C. Whitmore, both at Northwestern University. Some synthetic organic work and all the pharmacological part of the effort is under the supervision of Professor A. S. Loevenhart, of the University of Wisconsin. The clinical investigations are managed by Professor W. F. Lorenz, the director of the Wisconsin Psychiatric Institute.

An interesting feature of the chemical phase of the research has been the development of the Intermediate Laboratory. It occurred to Professor Whitmore that at least 90 per cent. of the research chemists' time was employed in making intermediate chemical substances necessary for the synthesis of the compounds desired. These intermediates are usually impossible to obtain, even from such specialized dealers as the Eastman Kodak Company. Accordingly, Northwestern University erected a small laboratory building in which two men devote their energy to making such intermediates as may be required by the synthetic chemists. This has resulted in a tremendous saving of money and time and insures a purity of intermediates impossible to obtain otherwise. With the increasing interest in this line of work, the large scale production of intermediates by this laboratory may become of great assistance to chemists outside of this particular group.

The actual chemical work in this cooperative research is proceeding in an exceedingly comprehensive and orderly manner. No compound is submitted for pharmacological study until its composition and structure has been accurately determined, until it has been purified with scrupulous care and until its physical and chemical properties are known.

The pharmacological investigation of compounds received at the University of Wisconsin involves several steps: (a) determination of toxicity on mice, rats, rabbits and guinea pigs; (b) estimation of therapeutic value in trypanosome infections in rats and rabbits; (c) estimation of therapeutic value in experimental rabbit syphilis and (d) determination of distribution in the tissues and rate of elimination from the body. If a compound is found to have therapeutic value, it is administered to the laboratory workers and to the director, in order to determine its rate and form of excretion and in order to ascertain whether or not it has any untoward effects in humans, before it is submitted to the clinical group for trial.

Upon reaching clinical service, a compound is again subjected to most careful study, of a somewhat different type. Hospitalized patients are selected for trial use of the drug. Attention has been paid generally to patients suffering from one of the many manifestations of syphilis of the central nervous system, but patients in other stages of syphilitic infection are also studied. The dosage to be employed is calculated from the experimental work, and the minimal amount from which therapeutic effects might be expected to result are used at first. If this is inadequate, the dosage is cautiously increased. Animal experimentation indicates the organs or tissues which are first affected by the drug when used in toxic amounts. The attention of the clinicians, therefore, is riveted upon the function which will first show any deleterious effects of the drug. In order to do this, specialized functional tests are employed. By such precautions, drugs may be excluded from human therapy without injuring a single patient.

The clinical and serological picture of these hospitalized patients is carefully watched, and special methods have been devised for detecting changes in the mental or physical condition. If the drug is successful in bringing about improvement in a large series of such cases, its indications and limitations are thoroughly considered and it may then be used upon selected ambulatory patients under the personal supervision of Professor Lorenz. When a year or more of painstaking clinical experience has been obtained with the use of the drug, it may be released, under control, to certain syphilographers, for use with patients for whom it may be indicated. If these confirm the previous findings, it may be considered for release to the general practitioner.

Complex organization of this sort requires frequent conferences for discussion of results and outlining of plans. The syntheses attempted by the chemical group are largely determined by the manner in which the compounds already studied may act pharmacologically. Fundamental problems on the relation between chemical constitution and pharmacological be-

havior must be attacked and solved. The many technical details connected with the use of a chemical substance in medical practice must be studied and met in the best possible manner. The question of solubility and stability is of utmost importance in work of this kind, and the resources of the chemist are often taxed to the limit in the effort to solve such difficulties.

Frequent conferences and open discussions are most helpful and inspiring in these matters. Those engaged in each phase of the work in this cooperative effort hold a weekly meeting, while monthly gatherings are called for the general force. The officials of the Public Health Institute try to meet with the research staff at least quarterly. This sounds almost like big business, but in this way the general effort is kept together, and mutual stimulus and inspiration are secured. The myopic vision of the individual is broadened by the use of the spectacles of his neighbor. The chemist feels he is doing something, when he actually sees a sufferer from general paralysis improve mentally and physically under the influence of the compound he has synthesized in consultation with the pharmacologist, who believes he knows how to improve the action of a substance previously made. When the Public Health Institute can help its patients in a manner previously impossible, it knows that its money has been well spent.

RESULTS

The results of scientific research are judged by the quality of the publications describing it. The results of this cooperative research have appeared in twenty-nine papers, published in the *Journal of the American Chemical Society* and in leading medical journals. Two more papers are in print, and at least a dozen articles are in preparation, including a comprehensive monograph describing the effort as a whole. Nine graduate students have obtained their doctorates partially through the research involved in the problem, while seven others are at present candidates for their doctorates on the basis of their work in this field.

It took about a year for the chemical staff to become oriented in this particular study and a somewhat longer time for the pharmacologists. The latter had to devise standardized quantitative methods for comparing the activity of one compound with another. This was an exceedingly important proposition and has been worked out so there can be no uncertainty about the relative merits of the substances studied. Qualitative comparisons are readily enough secured, but scientific men in general will appreciate the advantage of placing such comparisons upon a quantitative basis.

The most important achievement of this cooperative research which has been published to date was the finding that tryparsamide—the sodium salt of N-phenyl-glycine-amide-p-arsonic acid—is of great value in the treatment of syphilis of the central nervous system. This discovery has been heralded as the greatest advance in the therapy of syphilis since Ehrlich introduced salvarsan.

The steps leading up to this discovery are interesting. It occurred to Professor Loevenhart and Professor Lorenz that the therapy of neuro-syphilis might be an entirely different proposition from the therapy of general syphilis. Ehrlich's preparations (arsphenamine and neo-arsphenamine) are of no value in neuro-syphilis, although they are excellent in general syphilis. On this hypothesis, then, it was not logical to assume that an arsenical preparation would be of no service in neuro-syphilis merely because it is not beneficial in other forms of syphilis. Accordingly, the Wisconsin group began to study various arsenical compounds which had been discarded for use in the general types of syphilitic infection, for the purpose of ascertaining whether or not they might be employed in the therapy of syphilis of the central nervous system.

Among such substances investigated was tryparsamide, which was kindly sent by the Rockefeller Institute, along with two other compounds, for this purpose. Tryparsamide had been synthesized by Dr. W. A. Jacobs and Dr. Michael Heidelberger, of the Rockefeller Institute, and was described by them in 1919. Dr. Wade H. Brown and Dr. Louise Pearce, also of the Rockefeller Institute, studied its toxicity, observed its tonic effect in animals and made an exhaustive study of its therapeutic action in animal trypanosomiasis and rabbit syphilis. They also investigated its therapeutic value in late human syphilis, and Dr. Albert Keidel and Dr. J. E. Moore studied its action in early human syphilis. While it was found very efficacious in sterilizing an animal infected with trypanosomes, it gave disappointing results in human syphilis. It was received for study at Wisconsin in October, 1919, and it was quickly apparent that it had great possibilities of being beneficial in neuro-syphilis. Later, Dr. Pearce tried it with great success in the treatment of human trypanosomiasis or African sleeping sickness. After more than three years of careful clinical study with the drug in neuro-syphilis, Lorenz, Loevenhart, Bleckwenn and Hodges published their surprising results with it in May, 1923. Since then the findings of the latter have been abundantly confirmed.

To a certain extent, then, the hypothesis upon which Professors Loevenhart and Lorenz proceeded was justified. Tryparsamide is apparently unique

in bringing about a resolution of syphilitic lesions in the central nervous system, leading to astonishing clinical recoveries from paresis and even maniacal mental disorders. The saving to the state of Wisconsin alone, through the discharge of patients suffering from various forms of insanity occasioned by syphilis, who have been apparently permanently relieved of their mental disability, has already many times paid for the total cost of the entire research.

While the chemical phase of the cooperative effort has not as yet produced such startling results, it has contributed information of a fundamental character in organic research on mercurials and arsenicals. In the employment of new synthetic methods, compounds of arsenic have been obtained in which the well-known "tonic" action of arsenic has been attenuated to a remarkable degree, so that these substances give promise of being very valuable in the symptomatic treatment of emaciated patients. Many new facts concerning the toxicity of mercury compounds have been found.

Among the most important results of the pharmacological phase of this cooperative research has been the working out of a quantitative method for the comparison of the therapeutic value of the many different compounds studied. Qualitative estimations can not be expected to yield accurate knowledge upon as complex a problem as this, particularly when such estimations are limited only to a single criterion of therapeutic action. In the method devised by Professor Loevenhart and his associates, a standardized inoculation or infection is made; each treated animal is followed with a corresponding untreated but infected animal, and the dosage of the compound used is calculated from the maximum tolerated dose; the course of the blood Wassermann, the exact character of the initial lesion and the number of infecting organisms present at any one time are all accurately determined, and then, by means of a formula, the therapeutic value of the drug as compared to neo-arsphenamine (which has been arbitrarily selected as a standard) may be calculated. This method has yielded information impossible to secure by ordinary qualitative technique.

The routine blood Wassermann, which has been performed on all experimental rabbits, has given surprising knowledge of a fundamental character upon immunological reactions in general, and in particular upon the significance of the Wassermann reaction itself. This is being closely studied by Professor Lorenz at the present time.

Another interesting contribution from the pharmacological phase of this general research has been one by Dr. Albert Young and Professor Loevenhart, on the action of organic arsenicals upon the optic tract. It had long been supposed that the deleterious effect of organic arsenicals on the optic tract was due to the presence of pentavalent arsenic in the compounds. This work rather conclusively proved that injury is due to the presence of either trivalent or pentavalent arsenic in the para position to an amino or substituted animo group.

In Conclusion

It is felt by the workers concerned in this cooperative venture that the real effort is just beginning. The hopefulness of undertaking to find arsenical and mercurial organic compounds which might be better than anything yet known for the treatment of syphilis of the central nervous system has been justified, and this is provoking greater optimism for the future. So much promising study is in sight that enthusiasm among the group is increasingly evident at each meeting. It is hoped that this plain recital of the story of a working cooperative scientific research, with its implied disappointments and reverses, as well as with its successes, may prove to be the needed stimulus to the inauguration of similar efforts elsewhere.

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THE ANTIQUITY PHANTOM IN AMERICAN ARCHEOLOGY

INTEREST in American antiquities has increased rapidly in recent years, and researches are extending to many fields heretofore untouched. So fascinating is the lure of great antiquity that numerous untrained explorers are entering the field, and the highly colored accounts of their discoveries are broadcasted with fanciful elaborations by predatory journalists. We hear, for example, of numerous pre-Columbian discoveries of America; of ancient races preceding the Indians; of civilizations antedating those of the Nile and the Euphrates; of glyphic inscriptions miles in length that await a translator; of skeletons of men twelve feet in length; of dinosaurs and ibexes engraved on rock surfaces; of the ruins of a Chinese city; of America as the probable birthplace of humanity; and so on, *ad infinitum*. These fanciful announcements by untrained adventurers in the realm of science, being without chronological or other support, are soon forgotten, but when geological chronology is appealed to by explorers, whose statements and conclusions find a place in scientific journals, the case becomes more serious and deserves more than passing attention.

Recently there has come to my notice a brief ar-

ticle by F. B. Loomis,[1] published in the *American Journal of Science,* entitled "Artifacts associated with the remains of the Columbian elephant at Melbourne, Florida," which article should not be passed over without comment on the part of students interested in the much discussed question of the antiquity of man in America. This is especially true since the very limited evidence recorded is regarded by Mr. Loomis as conclusive proof of the Pleistocene age of the relics recovered—proof that man in Florida was contemporaneous with a great group of animals long since extinct. Reciting in some detail the recovery of the four specimens, illustrations of which are given, he assigns them without hesitation to the Pleistocene, and this notwithstanding the fact that all were obtained from superficial hammock deposits within three feet of the surface and are of types characteristic of the art of the Indian tribes of Florida.

It has been my practice during many years of archeological research to begin on the surface of the site under examination with the known peoples and their culture, following the story downward in the successive formations until all traces of occupation disappear; and I may state that in no case in many years of more or less continuous investigation in the American field have I found a trace of human handiwork not assignable with safety to the Indian tribes, historic or prehistoric, and none so deeply imbedded in geologically ancient strata as to preclude the possibility of introduction from recent horizons. I wish, therefore, to apply this method of approach to the Florida evidence under consideration.

Mr. Loomis's record of his finds is as follows: (1) a rudely chipped flint implement, the fragment of a leaf-shaped blade, a knife or spear head, found in a bed of sand three feet beneath the surface of the hammock and associated somewhat closely with the fossil bones of an elephant; (2) three bits of fossil bone bearing traces of human handiwork recovered from superficial beds of sand and muck as follows: a "handle" so completely worked that the original bone could not be identified; the radius of a deer deeply grooved lengthwise and girdled with a groove so as to be broken according to these guides; a tibia through which a hole had been partly drilled. These were found not far away in masses of hammock thrown up by a canal dredge.

It is well known that Florida has been occupied by the Indian tribes for many centuries. They built their mounds of earth, sand and available shell material and buried their dead in the mounds and in the superficial hammock. They fished in the streams and hunted game in the forests. In their villages they practiced their varied arts, shaping their implements, utensils and ornaments of every available material. It is thus to be expected that traces of their presence would be distributed throughout the superficial deposits to the depth of several feet. They quarried implement-making material wherever found, and the fossil bones, necessarily often exposed to view in the stream beds and in excavations, would, in a land of limited rock exposures, be a valued source of supply. That they utilized the fossil material in their arts and worked it in precisely the manner indicated in the Loomis finds is made clear by the researches of Clarence B. Moore, who, in his great series of works on the antiquities of Florida, illustrates a number of implements and ornaments carved from this material and recovered from Indian sites in the general region under consideration.

The bearing of these facts upon the finds of human handiwork associated with Pleistocene fossils requires discriminating attention. The fragment of flint blade is of particular interest—"it lay in the lower part of a bed of undisturbed sand, thirty-six inches below the surface." Numerous fossil bones occurred in the base of the sand layer which at the particular point was eight inches in thickness. "Both below and above this layer occurred layers of muck composed of leaves, wood, fine clay, sand, etc." The lower layer was considerably more than a foot in thickness and extended downward to the underlying marine marl. Mr. Loomis explains this rather extraordinary section of alternating sand and muck, with enclosures of fossil bones and the fragment of the flint implement, by assuming certain changes of level and resultant deposition, all of which he places within the Pleistocene period. At a particular stage, still within this period, "there was washed in, along with the sand, numerous bones, teeth, chips, implements, etc., all, however, being present in or near the swamps at the time." It may be questioned, however, whether the student whose researches in Florida seem to have been limited to a few feet of hammock deposits can speak with authority of the changes of level and the resultant depositions that have taken place not only during the Pleistocene, but during all post-Pleistocene time.

Passing over the question of the changes of level and their possible results, who shall say that a bed of sand, overlain by two feet of hammock, in a region occupied for uncounted centuries by the Indian tribes, has remained wholly undisturbed? The author's determinations regarding the geological conditions and

[1] *American Journal of Science,* Vol. VIII, December, 1924, page 503.

relationships are thus open to reasonable question; and it appears that his claim to authority in this branch is weakened by his manifest lack of archeological acumen. In describing the fragment of flint blade, with the evident purpose of enforcing his conclusions regarding Pleistocene antiquity, he observes that "the flint implement found with the mammoth bones is made of black chert, *roughly chipped and with none of the fine workmanship characteristic of the Indians.*" He is thus apparently unaware of the well-known fact that the Indians used chipped stone implements of every stage of rudeness and that indeed the broken implement found by him represents the type of blade most commonly used by the Indian tribes in their ordinary arts. The idea that either rudeness or refinement in the stone chipping art is exclusively characteristic of any period from the remote Paleolithic down through the ages to the present is no longer entertained by archeologists.

For half a century, that is to say, since the idea of the Paleolithic implement of Europe as a necessarily rude artifact gripped our American archeologists, every rudely chipped stone has been in imminent danger of assignment by its form alone to great antiquity; at the same time every relic of aboriginal art, reduced by accident to a more ancient horizon than that to which it belongs, has had to fight for its rightful place in the geological scale. When, forty years ago, I began my studies of the subject, I found that many of our institutions, including the National and Peabody Museums, had showcases filled with rudely chipped stones, the refuse of Indian workshops, labelled "American Paleolithic Implements." The controversy was bitter and long continued, but to-day it may be difficult to find in any museum, American or foreign, a single American specimen so labelled.

Geologists are slow to recognize the fact that human relics belonging on or near the surface are liable to intrusion by various means into older underlying deposits and that to very considerable depths. Florida furnishes a striking illustration of the danger of illy considered conclusions. We have here a series of unconsolidated deposits a few feet in depth resting upon undisturbed formations. The danger of intrusion of comparatively recent artifacts in these few feet is made apparent when we consider the activities of the Indian tribes as we know them, and also by the possible changes in superficial deposits by natural agencies. The Indians built their mounds of these deposits and buried their dead in them. They dug clay for their pottery and quarried materials for their implements. In this way objects of art were liable to introduction to the full depth of the deposits. It is also to be noted that the wounds made by these disturbances tended to heal rapidly, leaving no trace of the exotic origin of the objects enclosed. These objects are thus subject to discovery and misinterpretation by the unwary explorer. Natural agencies were also at work, complicating the conditions. Who shall say how often in a thousand years, for example, the meandering streams undermined their banks and rearranged the beds of sand and muck and their contents; who shall say what disturbances were due to the uprooting of trees and the burrowing of animals; and who shall say how often in a thousand years changes of level have taken place, how often the waters of the sea or of expanding inlets have rearranged the few feet of unconsolidated materials composing the hammock? All that archeologists need ask is that geologists, in their researches in Florida, allow for a zone or horizon of doubt extending to the full depth of possible intrusion from above, reserving their final determinations until the evidences are so conclusive as to be beyond danger of error. There can be no risk in this since, if there was a Pleistocene man there can be no question that in good time the evidence of his association with the Pleistocene animals will accumulate until overwhelming. It would be better to do this than to take the risk of imposing upon the world a mistake that might be difficult to eradicate.

Viewing the whole situation broadly, considering the failure so far to date the close of the Pleistocene and the fact that no trace of the great mammals is found in the pictographic or other art of the aborigines, there is good reason to hold that the flint blade found by Mr. Loomis was broken by a Florida Indian in the attempt to utilize bits of fossil bone in implement-making and at a period ten thousand or more years after the last elephant had disappeared from the forests of Florida. As the evidence stands to-day, and I have followed it closely, I can not accept it as conclusive, and unless geologists concede the danger of error and allow for a wide zone or horizon of doubt I shall feel it a duty to hold and enforce the view that the evidences of Pleistocene man recorded by Loomis at Melbourne, as well as those obtained by Sellards and others at Vero, are not only inadequate but dangerous to the cause of science. A similar attitude toward the illy considered announcements of followers of the phantom of antiquity should be rigidly maintained by all conservative students of the history of man in America.

W. H. HOLMES

SMITHSONIAN INSTITUTION

NOBEL PRIZES, PEACE AND PROGRESS OF SCIENCE

C'est l'ignorance qui sépare les hommes et la science qui les rapproche. PASTEUR.

THE recent celebration at Amsterdam of the semi-centennial of Van't Hoff's celebrated memoir on stereo-chemistry, the first of the scientific achievements which earned him in 1901, at the zenith of his career, the Nobel prize in chemistry, brought back to mind the address with which Van't Hoff opened the biennial meeting of Dutch scientists at Amsterdam in 1894. Van't Hoff compares the scientific advances made by the different nations, taking as his starting point a study by de Candolle, a Swiss botanist of French descent (1806–1893) who enumerates for each country at a given time the number of scientists who enjoy great reputation not only at home but also in foreign countries. His criterion is the distinction of being elected a member of distinguished foreign societies of learning. If one compares the numbers thus obtained with the total population of each country certain percentages are obtained and the following order results:

	1749	1789	1829	1869
(1)	Switzerland	Switzerland	Switzerland	Switzerland
(2)	Holland	Holland	Scandinavia	France
(3)	Scandinavia	Scandinavia	France	Germany
(4)	France	France	Germany	England
(5)	England	Spain	England	Scandinavia
(6)	Italy	Italy	Holland	Belgium
(7)	Germany	Belgium	Italy	Holland
(8)	Spain	United States	Belgium	Italy
(9)	Russia	England	Hungary	United States

This method is very fair since it takes up the scientists in the list of their time, for, as Van't Hoff remarks, famous names become gradually smaller, especially in natural sciences, where each succeeding discovery overshadows what precedes.

The remarkable thing about this table is that the small countries top the list, the larger countries with one exception, where France takes second place, being relegated to third and lower places.

A recent compilation in SCIENCE (January 30, 1925, p. 117) by F. Cajori, who attacks the problem from another angle, leads to similar results. Cajori bases his conclusions on the third volume of Poggendorff's Handwoerterbuch which gives the names of research men and the titles of their papers (for the exact sciences) from 1858 to 1883. Computing the number of scientists for every million of population (in 1870) we find that around 1870 the standing of the different nations was in the order: Switzerland, Holland, Germany, Sweden, England, France, Austria, United States, Italy and Russia.

It occurred to the writer that in the awards of the Nobel prizes, the highest recognition that can be given to any scientist, we have a suitable standard by which we can measure the scientific standing of the different nations during the past 25 years.

If we confine ourselves to natural sciences only (physics, chemistry and medicine) to make comparison with de Candolle's and Cajori's results possible, we see that in number of prizes Germany heads the list with 24, followed by France (12), England (11), Holland (6), Scandinavia (6) [divided as follows: Denmark (3), Sweden (3), Norway (0)], United States (4), Switzerland (2), Austria (2), Canada (2), Belgium (1), Spain (1), Italy (1) and Russia (1).

Dividing again by the number of inhabitants (in 1910) we find the following order: Holland, Switzerland, Scandinavia, Austria (assuming six million inhabitants for what is now the republic Austria), France, Germany, Canada, England, Belgium, Spain, United States, Italy, Russia.

The rôle of the small countries in the commonwealth of nations in the light of the foregoing statistics is strikingly illustrated. On a percentage basis Switzerland, Holland and Scandinavia have, time and again, contributed more to the progress of science than any other country and the fact that these small countries have enjoyed undisturbed peace over longer periods than their neighbors is not without significance. That Holland was chosen for the seat of the International Court and Switzerland for permanent residence of the League of Nations was nothing but a universal recognition of the importance of these small nations as natural traits d'union between the large, powerful and often antagonistic countries surrounding them. If we accept Pasteur's dictum that it is ignorance that separates the peoples of this earth and science that brings them together, then the exponents of Scandinavian, Dutch and Swiss science by their knowledge of the language and the progress of science in other countries can lay claim to a large share in the promotion of peace and progress throughout the world.

H. S. VAN KLOOSTER
RENSSELAER POLYTECHNIC INSTITUTE

SCIENTIFIC EVENTS

THE SEVENTH MEETING OF THE INTERNATIONAL COMMISSION OF EUGENICS

THE September number of *Eugenical News* gives an account of the annual meeting of the International Commission of Eugenics which was held in the rooms of the Royal Society, Burlington House, London, on July 14 and 15, under the presidency of Major Leonard Darwin. There were present the secretary-treasurer, Dr. A. Govaerts, besides the assistant secretary, Mrs. C. B. S. Hodson. Other members of the commission were: From Belgium, Dr. F. Ensch; from Denmark, Professor W. Johannsen; from France, M.

Lucien March; from Great Britain, Sir Bernard Mallet; from Italy, Dr. Corrado Gini; from Netherlands, Dr. Marianna A. van Herwerden and Dr. G. P. Frets; from Norway, Dr. Jon Alfred Mjøen and Professor Collin; from the United States of America, Dr. C. B. Davenport.

Business was conducted on August 14 and 15. The commission was entertained at lunch by Major and Mrs. Darwin on both days. On the afternoon of the fourteenth a visit was made to the Zoological Garden of the Zoological Society of London and delegates were entertained at tea by Professor E. W. MacBride and Mrs. MacBride. On the afternoon of the fifteenth the MacBrides entertained the commission at their house. In the evening Dr. J. Mjøen gave an address at the Royal Society on "Inheritance of the elements of musical ability."

The commission voted to change its name to the "International Federation of Eugenical Organizations." The rules of the commission were altered so as to permit a possible fourth member from a country. It was decided to cooperate with the League of Red Cross Societies by appointing as representative M. March. It was also voted to authorize the president to call conferences at the time and place of any meeting of the federation. Dr. van Herwerden's proposition for standardization of pedigree charts was considered and Drs. van Herwerden and H. H. Laughlin were constituted a committee to arrange for the publication of these standards. Professors E. Pestalozza and Cesare Artom were nominated to membership in the commission by Professor Gini as representatives of the Eugenical Society of Italy. Dr. Gini brought up for discussion the matter of synoptic publications on eugenics from each of the different countries, for which service he has secured a publisher. The matter of registration having been urged by Dr. Mjøen, a committee on registration was appointed. Professor Collin made a report upon biosociology and the question of the rise and decline of nations. The matter of the place of the next meeting of the commission was left undecided as between Philadelphia and Paris.

THE EXPOSITION OF CHEMICAL INDUSTRIES

THE Exposition of Chemical Industries will be held from September 28 to October 3 in the Grand Central Palace, New York City. Last year this exposition was not held. It is expected that the 1925 exposition will offer more to chemists and chemical engineers in the line of new equipment, new methods and new materials than any previous exposition.

Of great interest among the new features arranged for the exposition will be the court of chemical achievement, designed to bring together in one great group the outstanding developments of recent years in chemical processes, products, instruments and equipment. For the honor of being awarded a place in this muster of eminent achievement there were hundreds of applications from all parts of the country, and the selections made during the past week by the approval committee of the American Chemical Society are of interest to the chemical industry. Since no foreign products will be admitted to this court of honor, the display will be a complete epitome of the recent progress of American chemistry, giving the public in general a clear idea of what constitutes the most important and meritorious advancements in this line.

Several hundred different products will appear in this exhibit. The United States Bureau of Chemistry, for instance, will show the method it has developed for the fumigation of grain against weevils; a series of by-products from corncobs and several other involved technical processes. The U. S. Chemical Warfare Service has had six of its developments honored by selection, including devices for producing screening smoke; tear-gas munitions, the scientific name for the latter being C. N. Chloracetaphenone; the chlorine treatment in respiratory diseases, and various new types of gas masks and canisters.

Low-freezing nitro-glycerine explosives and a smokeless shotgun powder are among the several products of the E. I. duPont de Nemours & Co., honored by selection. The method of commercial manufacture of metallic tungsten developed by the Fansteel Company of Chicago also finds a place on the list, and the American Protein Corporation gets in with its three new products—fibrin, haemoglobin and serum albumin.

Selenium flame proofing for insulating electric wire, an important advance in fire prevention, places Arthur D. Little, Inc., in the list of those honored by selection. Another single product, a method of impregnating fabric with rubber by spraying known as sprayed rubber, gives the U. S. Rubber Company a place in the Court of Honor. The Bakelite Corporation's product of the same name has been selected, as well as the Corning Glass Company's pyrex ware, and the Bausch & Lomb Optical Company's optical glass. Two hundred and fifty-nine chemical products of the Eastman Kodak Company are considered as achievements, but because of the large number the committee has not yet made the list public.

NATIONAL CONFERENCE ON PHARMACEUTICAL RESEARCH

THE fourth annual meeting of the National Conference of Pharmaceutical Research was called to

order by Chairman Arny at Hotel Fort Des Moines, Des Moines, Iowa, on August 22.

Reports were presented by the chairmen of seven of the ten standing committees of the Research Conference, those reporting being:

Committee	*Chairman*
Standardization of U. S. P. and N. F. Pharmaceuticals	W. L. Scoville
Manufacture of U. S. P. and N. F. Chemicals	H. A. B. Dunning
Standardization of U. S. P. and N. F. Chemicals	C. H. LaWall
Sources of Identification of Botanic Drugs	H. W. Youngken
Standardization of Botanic Drugs	E. L. Newcomb
Chemistry of Drug Plants	W. O. Emery
Business Research in Pharmacy	Ambrose Hunsberger

A motion was passed directing the chairmen of these committees to act as a committee of ten to report back next year as to the advisability of rearranging the ten committees with the aim of avoiding duplication of work. Mr. Newcomb presented a resolution endorsing the Pharmacy Building Campaign and urging all members of affiliated bodies to subscribe to the fund. This resolution was passed by the conference by unanimous vote. A committee, consisting of Messrs. Day, Snow and Whelpley, then presented a minute of sorrow over the passing of Dean L. E. Sayre, an active supporter of the Research Conference since its organization. The minute was adopted by a rising vote.

The census of research of 1925 was approved and the chairman was directed to conduct a similar census in 1926. Slight changes in style of publishing the census were directed.

Acting-Secretary Krantz brought up the question of a book in popular style describing the research achievements of pharmacy. After animated discussion, the research conference endorsed the idea and directed the appointment of a committee to formulate plans and to submit the same to the American Pharmaceutical Association and other national bodies likely to be interested, with a request that these organizations undertake the publication of such a book. Under the topic "Research funds" attention was called to the American Pharmaceutical Association Research Fund, the recently created Remington Research Fund of the United States Pharmaceutical Convention and to the newly designed Ebert Medal which will replace the cash prize from the Ebert Fund awarded by the American Pharmaceutical Association each year for the best paper presented at the meeting of the association.

The nominating committee presented the following names for officers for 1925–26: *Chairman,* H. V. Arny, of New York; *Vice-chairman,* J. H. Webster, of Detroit; *Secretary-Treasurer,* J. C. Krantz, Jr., of Baltimore. The nominees were duly elected by the research conference.

The research conference adjourned to meet again, if possible, on the Saturday following the 1926 meeting of the American Pharmaceutical Association.

NATIONAL RESEARCH FELLOWSHIPS IN THE BIOLOGICAL SCIENCES

AT its fall meeting, held in Wood's Hole, Massachusetts, on September 5, the board of National Research Fellowships in the Biological Sciences made four appointments, namely: Harry R. DeSilva in psychology, Walter N. Ezekiel in botany, L. J. Klotz in botany and Miss Nellie M. Payne in zoology. Also, Miss Helen Redfield, whose appointment did not begin until last January, was reappointed for a second year, to take effect January 1, 1926.

It is planned to hold the next meeting of the board toward the end of February or early in March instead of at the end of April as has been the practice heretofore. Applications for consideration at this meeting should be in the hands of the board not later than February 1, 1926. It is further anticipated that a second meeting for the year 1926 will be held in June rather than the following fall. Information and application forms for the fellowships may be obtained by addressing the secretary, Board of National Research Fellowships in the Biological Sciences, National Research Council, Washington, D. C.

FRANK R. LILLIE, *Chairman,*
Board of National Research Fellowships in the Biological Sciences

SCIENTIFIC NOTES AND NEWS

MEMORIAL services for the late Dr. John Mason Clarke, formerly head of the New York State Museum and state paleontologist, will be held in connection with the sixty-first annual convocation of the University of the State of New York, at Albany, on October 15. The principal speaker will be Dr. Charles D. Walcott, secretary of the Smithsonian Institution. Charles B. Alexander, a member of the State Board of Regents, will preside and there will be other speakers, to be announced later.

DR. FRANK SCHLESINGER, director of the Yale Observatory, who went to Johannesburg to set up the Yale telescope, has returned to the university after an absence of nine months.

DR. HEBER D. CURTIS, director of the Allegheny Observatory, will sail from San Francisco on September 26, on his way to Sumatra, where he is going to observe the eclipse of January 14 next.

A TABLET was recently unveiled on one of the principal streets of Valencia in honor of Dr. Ramón y Cajal, the distinguished Spanish histologist, who shared with Golgi the Nobel prize in 1906.

PROFESSOR F. MEYER, of Königsberg, and Professor C. Runge, of Göttingen, both mathematicians, have retired from active teaching.

THE Indian government has selected Lieutenant-Colonel F. P. Mackie, director of the bacteriological laboratory of Bombay, and Drs. A. Souza and B. B. Brahmachari, assistant directors of public health in the United Provinces and Bengal, respectively, to take part in the tour in Japan this autumn of public health officers of the Far East. The tour is under the auspices of the League of Nations.

JOSEPH W. ROE, head of the department of industrial engineering at New York University, has been appointed by the administrative board of the American Engineering Council chairman of a committee to investigate the aviation situation in the United States. The council plans to raise $100,000 for the work of the committee.

PROFESSOR G. PÓLYA, of the Zurich Technical School, has been awarded a Rockefeller traveling fellowship for a year's residence at Oxford and Cambridge.

EDWIN R. MARTIN, assistant professor of electric power engineering at the University of Minnesota, has resigned in order to enter the industrial power division of the Westinghouse Electric & Manufacturing Company at East Pittsburgh.

A. R. LAMB, chief in nutrition at the Iowa Agricultural Experiment Station, took charge of the research department and of the experimental farm for the Moorman Manufacturing Company at Quincy, Illinois, on September 1.

DR. J. W. GIDLEY, of the U. S. National Museum, has been detailed to the Bureau of American Ethnology to make a preliminary examination of a site in the vicinity of Lawton, Oklahoma, where mammoth teeth have been lately found, to determine whether human remains occur with these fossils and to ascertain to what geological formation they belong.

DR. KURT KONSTANTINOWSKY, lecturer in physics at the University of Vienna, Austria, and Hugo Sonnenfeld, chief engineer and general superintendent of the Cable Manufacturing Company, Ltd., Bratislava, Czechoslovakia, are at present on a tour of the United States with the purpose of studying American cable practices.

DR. E. AITKEN SEAGAR, lecturer in tropical hygiene and sanitation in the Imperial College of Tropical Agriculture in Trinidad, B. W. I., has been spending a few weeks in the United States as a guest of the International Health Board of the Rockefeller Foundation.

DR. K. SUGIMOTO, a rice expert attached to the Tokio Nutrition Laboratory, is visiting the United States under the auspices of the Rockefeller Foundation.

A RUSSIAN scientific expedition headed by Professor Liebedev is to make a geological survey of Northwest Mongolia at the request of the Mongolian government. The expedition plans to continue the systematic survey of the country started in 1923 by M. Ratchkovsky.

PROFESSOR ALEXANDER FINDLAY, of the University of Aberdeen, addressed the Chicago section of the American Chemical Society on September 18, taking for his subject "The appeal of science to the community."

DANIEL RANKIN STEWART, late chief chemist to the Broxburn Oil Company and known for his work on the chemistry and technology of shale oil and petroleum, died on August 1, aged seventy-seven years.

THE death on July 29, at the age of eighty-seven years, is announced of Professor H. Hildebrand Hildebrandsson, the distinguished meteorologist who was formerly director of the Meteorological Observatory at the University of Upsala.

THE death was recently announced of Professor Oscar Brefeld, formerly professor in the University of Berlin and for fifty years a leader in modern mycology, at the age of eighty-six years.

THE general headquarters for the Interstate Post Graduate Assembly of America, which meets in St. Paul from October 12 to 16, will be the St. Paul Auditorium. We learn from the *Journal* of the American Medical Association that among the distinguished foreign speakers on the program will be Lord Dawson of Penn, London, England, personal physician to the king; Sir William Arbuthnot Lane, of London; William Blair Bell, professor of obstetrics and gynecology, University of Liverpool, England; Professor Vittorio Putti, Bologna, Italy; Dr. Henry L. McKisack, Royal Victoria Hospital, Belfast, Ireland, and Dr. W. H. Parkes, Auckland, New Zealand. There will be diagnostic clinics and discussions by prominent physicians in this country and Canada, and at the banquet there will be addresses by distinguished citizens from this and other countries. The hotel headquarters will be at the St. Paul Hotel.

THE President's Muscle Shoals Commission has been called to meet on October 1 and will remain in

continuous session until its report is completed. The commission, which is to make recommendations for the final disposition of the government's property at Muscle Shoals, is composed of former Representative McKenzie, of Illinois, *chairman;* former Senator Dial, of South Carolina; Professor H. A. Curtis, of Yale University; William McClellan, consulting engineer, New York, and Russell F. Bower, of the American Farm Bureau Federation.

THE Eleventh International Congress of Hydrology and Climatology will be held at Brussels from October 10 to 14, under the presidency of Professor Gilbert, of Paris, and Dr. Terwange, of Brussels. The following subjects will be discussed: hydromineral and climatic treatment of cardiovascular affections, introduced by MM. Cottet-Mougeot and Piatot; hydromineral sulphur cure, introduced by MM. Flurin, Liacre and Lamorgue. The subscription is 50 francs for members of the congress and 25 francs for ladies accompanying them.

THE second session of the Australasian Medical Congress (British Medical Association) will be held in Dunedin, New Zealand, from February 2 to 9, 1927, in the new medical school at present under construction, and will be opened by Sir Charles Fergusson, Governor-General. The president of the congress is Dr. L. E. Barnett, emeritus professor of surgery in the University of Otago, and he will be assisted by an executive committee including Dr. D. E. Carmalt-Jones as honorary treasurer, Dr. W. P. Gowland as honorary general secretary, and Dr. A. M. Drennan as honorary associate secretary. The scientific proceedings will be conducted in twelve sections. Provision will be made for a trade exhibition of books, instruments, drugs, etc. Those desiring further information in regard to the congress and firms desirous of cooperating in this exhibition are requested to communicate with Dr. W. P. Gowland, honorary general secretary, Australasian Medical Congress, Dunedin, New Zealand.

AT the recent bi-centenary celebration of the Russian Academy of Sciences, Michael Kalinin, president of the Soviet Republic, announced that in recognition of the scientific work of the academy, the government had declared it a national institution of the Soviet Federation. He said that the world was interested in the work of the Russian scientific men, but that thus far its interest had been modest, due largely to the low standard of education which prevailed in Russia, but which the Soviet was rapidly remedying.

THE tropical Plant Research Foundation of Washington has undertaken an investigation of forestry problems in Cuba, with the support of the United Fruit Company and The Cuba Company. A survey of portions of the Oriente Province will be begun by Dr. H. N. Whitford.

THE publication of a new *Archive of Eugenics* from the Galton Laboratory is announced by Professor Karl Pearson.

BETWEEN now and next spring thirty-nine million trees will be planted in Great Britain as part of the forestry department's program for restoring the rapidly disappearing forests. The department has planted 52,500 acres in trees. A new forest of 24,000 acres is being made out of waste land in Norfolk, which is being planted with fir and spruce.

THE Central Ethnographical Museum of Moscow is organizing two scientific expeditions. One of them will study the ethnography of the Eastern Finns, Mari, Vetiaks and Mordvans. Another expedition has gone to the Caucasus for similar studies in the Circassian and Kabardin-Balkan regions.

ROALD AMUNDSEN has made an agreement with Italy for the use of that nation's modern dirigible No. 1 for a polar flight next March. He has been in Rome recently conferring with Premier Mussolini, the under secretary of aeronautics of the ministry of war and other officials, and finally has completed the agreement, which is said to be advantageous to Italy, inasmuch as the dirigible will be manned largely by an Italian crew and pilots, although it will fly the Norwegian flag. The dirigible is already being put in commission for the trip, with slight modifications in the technical equipment, as suggested by Amundsen. The airship was built in 1924, is 348 feet long, 85 feet in diameter and holds 671,000 cubic feet of gas, and has an average speed of 62 miles an hour. It is driven by three 250 horsepower motors and will carry a cargo of eight tons. In addition to its crew it can carry about twenty passengers.

ACCORDING to *Nature* the Soviet of Commissars of the U. S. S. R. decided on July 28 that, for all foreign visitors invited to the celebration of the bicentenary of the Russian Academy of Sciences, arrangements should be made for free travel on all the railways and waterways of the union, for sleeping-cars on the direct communication routes, for seats, and for first-class cabin accommodation on all the sea and river steamers from August 15 until October 1. These facilities will depend on the production of a foreign passport, with the visa of the plenipotentiary representatives of the Union abroad, or of the general consulates of the U. S. S. R., with the inscription, "For the celebration of the Academy of Sciences." Besides free travel facilities, the production of a passport and visa thus inscribed also obtained

without waiting reserved seats in express trains and luggage transport. These passports were thus considered in the present case equal to the yearly certificates of members of the central executive committee of the U. S. S. R. Special reception committees at the frontier stations (including Odessa) met foreign guests proceeding to the celebration as soon as they disembarked and assisted in getting the necessary tickets or reserved seats without delay.

A BILL providing for "an inventory of the water resources of the United States" will be introduced at the forthcoming session of congress, according to the *Electrical World*. The proposed legislation authorizes the director of the United States Geological Survey to make this inventory for use in setting up a comprehensive plan "for developing both surface and ground waters for domestic and industrial supplies, irrigation, navigation, power and other uses and for the conservation and control of flood water." An appropriation of $400,000 is sought for the first year's work and $500,000 for each year for nineteen years thereafter. The purpose of the bill is to expand the work of the water resources division of the Geological Survey and vest in that agency, among other things, the authority to make a general survey of the country's streams. An ineffectual effort was made at the last session to obtain legislation which would have enabled the Federal Power Commission to make such a survey, using license fees for the purpose. The Power Commission and the Corps of Engineers, however, were directed to report to Congress the cost of such a survey.

A SCIENTIFIC deep sea expedition which left Hamburg in April recently arrived at Cape Town after a successful cruise. The expedition traversed the Atlantic between America and Africa fourteen times and succeeded in studying scientifically submarine currents. The claim is made that this is the first time this has been accomplished. Reports from the expedition declared that its investigation proved that warm currents from the north Atlantic flow at a considerable depth for a distance of about 2,000 miles south of the equator, where they rise to the surface. Similar currents from the southern polar regions pass northward. The waters of these currents were found to contain such forms of organic food as is sought by whales and certain other fish. The expedition, financed entirely by private subscription, is in charge of Dr. Metz, director of the Berlin Institute of Oceanography. It will proceed to the southern Polar regions, making Bouvet Island its base and sailing eastward from there.

AT the 1924 meeting of the National Conference on Pharmaceutical Research the executive committee of that organization was directed to take a census of pharmaceutical research. Accordingly a questionnaire was prepared for distribution and was sent to some 270 persons interested in pharmaceutical research. These question sheets brought returns which when tabulated recorded the names of 239 research workers who may be classified as follows: Hospital pharmacists, 3; retail pharmacists, 10; pharmacists, engaged in medical school and chemical school work, 16; governmental scientists doing pharmaceutical research, 19; non-pharmaceutical teachers and students doing pharmaceutical research (chiefly on the synthesis of medicinal chemical), 28; manufacturing pharmacists, 72; pharmaceutical teachers and their students, 91.

ACCORDING to *Eugenical News*, the Royal Academy of Science at Amsterdam has nominated a commission charged with the examination of the total physical anthropological status of the Netherlands. Professor Bolk, anatomist at Amsterdam, is chairman. The government has added to this commission the medical general-inspector of the navy and army. The commission has been divided into five sub-commissions—(a) historical anthropology, (b) head-index, (c) pigmentation, (d) length and (e) biochemical indices—and hopes to terminate the work in from four to five years.

UNIVERSITY AND EDUCATIONAL NOTES

AN estate of $550,000 was recently bequeathed to the University of Wisconsin by the late J. Stephen Tripp, of Prairie du Sac.

THE will of the late Charles W. Eaton, of Haverhill, gives the major portion of his estate, estimated at $300,000, to the Massachusetts Institute of Technology, to be used for the advancement of the general purposes of the institution.

AN endowment fund of $100,000 to maintain the surgical research laboratory in connection with the school of medicine of the University of Kansas is provided in the will of the late Mrs. Nellie S. Boylan.

PROFESSOR HENRY T. MOORE, head of the department of psychology of Dartmouth College, has been elected president of Skidmore College, Saratoga Springs, N. Y., to succeed the late Dr. Charles H. Keyes. Professor Moore was recently elected to a professorship at the University of Michigan, from which he is seeking a release.

DEAN HAROLD S. BOARDMAN, of the College of Technology at the University of Maine, has been elected acting president of the university to fill the vacancy caused by the resignation of Dr. Clarence C. Little.

PROFESSOR A. A. BENNETT, of the University of Texas, has been appointed head of the department of mathematics at Lehigh University.

DR. ROBERT CALVERT has been appointed head of the industrial chemistry division at the University of Maryland.

DR. LEROY T. PATTON, associate geologist of the bureau of economic geology and technology of the University of Texas, has been appointed professor and head of the department of geology of Texas Technological College at Lubbock, Texas.

DR. G. G. NAUDAIN, of Iowa, has been appointed professor of chemistry at Kansas State Teacher's College, Pittsburgh, Kansas.

AT George Washington University, Dr. Colin M. Mackall, of St. Johns College, Annapolis, has been appointed professor of chemistry and James R. Randolph, of the U. S. Bureau of Standards, assistant professor of mechanical engineering. Dr. Franklin L. Hunt, of the U. S. Bureau of Standards, will give lectures on physics and Dr. James R. Eckman on chemistry.

PROFESSOR H. TIETZE, of the University of Erlangen, has been appointed to a professorship of mathematics at the University of Munich.

PROFESSOR HANS EPPINGER, of the first medical clinic at the University of Vienna, has been called to the chair of internal medicine at the University of Prague.

DISCUSSION AND CORRESPONDENCE

THE CONSERVATION OF MOMENTUM AND THE WIDTH OF CRITICAL POTENTIALS DETERMINED BY THE METHOD OF ENERGY LOSS

IT is readily deduced from the law of the conservation of momentum that when two bodies of widely different masses collide, either elastically or inelastically, the velocity of the heavier undergoes little change. Hence, if the collision is inelastic, the increase in internal energy of the masses is almost entirely at the expense of the kinetic energy of the smaller. But if the masses are comparable, then the velocity of both is altered and the internal energy is increased at the expense of the kinetic energy of each in an undetermined proportion. The kinetic energy of one mass may even be increased beyond its initial value while that of the other is decreased by a correspondingly greater amount.

These remarks bring to light a possible reason for the failure to detect the excitation of atoms by high speed positive ions, using the method of energy loss, for the success of the method depends entirely on the fact that an electron retains almost the entire excess of energy after an inelastic collision. The apportionment of the excess between ion and atom will lead to a blurring of the critical potential. A further complication results from the fact first pointed out by Franck,[1] that an ion of mass m must possess energy to amount $\frac{m+M}{M} V_R$ in order to excite a stationary atom of mass M and critical potential V_R.

It may be shown that the width of the blurred critical potential is

$$\Delta V' = \frac{4\,m\,M}{(m+M)^2}\sqrt{V\left(V - \frac{m+M}{M}V_R\right)}$$

where V is the energy of m before impact. The center of the band is at

$$V' = \frac{m^2+M^2}{(m+M)^2}V - \frac{M}{m+M}V_R$$

Taking the case of mercury, $V_R = 4.6$v., $M = m$, and $V = 10.2$v (one volt above the minimum): $\Delta V' = 3.2$v., $V' = 2.8$v. The process will therefore result in the formation of low velocity positive ions of no definite energy, rather than in a homogeneous group.

Actually, the method of energy loss is one of great experimental difficulty when applied to positive ions, and has seldom been used. Consequently the failure to detect their action experimentally must be sought elsewhere. It is suggested that their great mass may be a sufficient cause for low probability of inelastic impact.

The inability of this method to detect ionizing potentials follows from similar considerations. In this case the energy in excess of the critical potential must be shared between the ionizing and ionized electron, resulting in a group of electrons whose energy is distributed in an unknown manner between almost zero and almost the entire excess energy. On any reasonable assumption, the distribution will possess a maximum at one half the excess energy. This would account for the presence of some of the pseudo-Maxwellian electron groups of high temperature found in discharge tubes by Langmuir and his coworkers. The very low velocity electrons observed by Eldridge[2] and attributed to the process of ionization are not explained.

CARL ECKART

EDISON LAMP WORKS,
HARRISON, N. J.,
AUGUST 14, 1925

[1] *Zeit. f. Phys.*, June, 1924.
[2] *Physical Review, 20,* 456 (1920).

ULTRA-VIOLET LIGHT AND THE OXIDATION OF COD LIVER OIL

IN these columns a year ago appeared a note,[1] stating that ultra-violet light is emitted when cod liver oil is oxidized. Careful experiments in this laboratory have failed to confirm these findings.[2] With an absolutely gas-tight camera, no darkening of a photographic film could be discerned after bubbling oxygen through cod liver oil in a quartz cell for ten days.

In other experiments the cod liver oil was heated to 100° C. while oxygen was passed through for three days, but no trace of a photographic effect was registered. The oxidation was sufficient to change the character of the oil as shown by a change in its iodine number.

The oxidation of para brom-phenyl magnesium bromide under identical conditions gave a distinct shadow of the cross wires behind the quartz lens, with an exposure of only two minutes. This reaction is known to be luminescent[3] and the positive effect proved that the apparatus was working properly. Feeding experiments in the laboratory of Professor H. Steenbock proved that the cod liver oil used was effective in curing rickets.

The reported evolution of oxygen by the action of ultra-violet light on oxidized cod liver oil was not found, when precautions were taken to drive out the dissolved air.

In connection with recent comments on this subject[4, 5] it should be emphasized that ordinary chemical fog ("Russell effect"[4]) is readily produced if reducing or other chemically active gases are allowed to come in contact with the photographic film.[6] In all our experiments the utmost care was taken to eliminate ordinary chemical fog as a factor, because in our early experiments we found that a fine mist of cod liver oil and vapors from asphaltum paint or beeswax acted chemically on the film to give a darkening on development and that these false images simulated the apertures through which the vapors had diffused.

It does not seem likely that black body radiation could have affected the photographic plates, as suggested,[3] unless they were especially sensitized to the infra red. No effect of this kind was observed in our experiments, although the cod liver oil and its container were heated to 100°, at which temperature the black body radiation should have been much greater.

1 Kugelmass and McQuarrie, SCIENCE, 60, 272, 1924.
2 Details are given in B. S. Thesis, 1925, Univ. Wis.
3 Evans and Dufford, *J. Am. Chem. Soc.*, 45, 278, 1923.
4 Kugelmass and McQuarrie, SCIENCE, 52, 87, 1925.
5 West and Bishop, SCIENCE, 52, 86, 1925.
6 Mathews and Dewey, *J. Phys. Chem.*, 17, 230, 1913.

It is unfortunate that the erroneous conclusions of the original article,[1] in spite of their correction,[4] should have led to such widespread speculation concerning the mechanism of the cure of rickets.

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THE THIRD STAGE OF DIGESTION IN PARAMECIA

APPARENTLY the earliest attempts to demonstrate the acidity or alkalinity of the protozoan food vacuole were made by allowing the organism to ingest small grains of litmus powder and noting the color change which the ingested fluid induced in the individual granules. Later, when the use of aniline dyes became common in the field of microchemistry, solutions of neutral red replaced both litmus and the somewhat capricious and unreliable indicator alizarin-sodium-sulphonic acid for the detection of acid and base in microscopic preparations. The studies which have been made of the reaction of the food vacuole of protozoa and the bolus of food within with the above-mentioned micro-indicators have resulted in the dictum now generally taught and accepted that in paramecium, at least, there are two stages of digestion—an initial one during which the prey is supposed to be killed in an acid fluid and a second or digestive-absorptive stage in which the food vacuole is alkaline.

In paramecia (either caudatum or aurelia) grown in hay infusion or in malted milk, acid solutions of phenolsulphonaphthalein can be seen flowing down the gullet in a yellow stream to distend the nascent food vacuole. As the stream passes through the narrow end of the gullet, just before entering the vacuole, evidences are visible of the beginning of a distinct alkaline reaction in part of the fluid. The borders of the stream next to the wall of the gullet become faintly but distinctly pink. The ingested bacteria which are colored yellow by the dye are carried into the newly formed food vacuole which is filled with an *alkaline* fluid. As the vacuole is freed from the gullet and moves off into the cytoplasm, it becomes slightly smaller and at the same time the alkalinity of the contained fluid becomes more pronounced, perhaps from concentration resulting from the passage of water from it into the cytoplasm, an increased alkalinity which is indicated by a deepening of the color in the dye-containing fluid. The alkaline reaction in the food vacuole persists until the vacuole turns to begin its journey to the anterior end of the organism when the pink color, which has become paler, is changed to the yellow tint which de-

notes an acid reaction in solutions of phenolsulphonaphthalein. The cytoplasm of the bacteria within the vacuole retains its acid reaction unchanged throughout the initial alkalinity of the ingested fluid. As the vacuoles continue their course, the acid yellow of the phenolsulphonaphthalein becomes more and more intense until as the anal spot is approached the reaction may again change and the vacuolar content once more take on the alkaline color. When this stage is reached the chromogen solution in the vacuole is highly concentrated and the food or fecal mass is permeated with the dye and shows also the alkaline reaction of the vacuolar fluid.

In short, a preliminary digestive period characterized by decided alkalinity of the fluid which forms the food vacuole can be recognized in paramecia if sufficiently sensitive indicators are introduced into the fluid which the animalcule ingests. The significance of this initial alkalinity and the part it plays in the metabolic activities of the organism is at present obscure.

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THE AMERICAN TYPE-CULTURE COLLECTION

THE curator of the American Type-culture Collection is preparing a tentative catalogue of the collection, which will be available for free distribution in a short time. This catalogue will be made the basis of a more complete and detailed catalogue which will be published after the collection is made more comprehensive, and corrections can be made in the nomenclature of the present lists.

The collection now includes over 400 cultures of bacteria. About 50 molds and 100 yeasts are also available.

Requests for the catalogue should be addressed to Dr. George H. Weaver, curator, John McCormick Institute for Infectious Diseases, 637 South Wood Street, Chicago, Illinois.

L. A. ROGERS,
Chairman

QUOTATIONS

SCIENCE AT SOUTHAMPTON

THE first object of the British Association is to direct attention to the greater recent achievements of science. Through the addresses of its leaders at each annual meeting it attains a wider publicity than its local audience and, at the same time, acts as a missionary to stimulate local interest and local effort. At the Southampton meeting, which ended recently, the president, Professor Horace Lamb, maintained the highest traditions of his predecessors. In simple but vivid language he reminded all whom it concerns—and it concerns us all—that science must not be pursued or encouraged merely or chiefly for the immediate dividends of material advantage which it often pays. It must be pursued for its own sake, as part of the human effort to comprehend the world of phenomena. Then, turning to geodesy, a subject so remote that even its name was unfamiliar to many, he explained recent additions to knowledge of the structure of the earth which have been won by a combination of mathematical discipline and physical observation. There is no need to attempt to summarize in phrases the addresses of the thirteen sectional presidents; they have been described day by day in our columns. Some, such as the address delivered by Dr. Simpson, government meteorologist, described an unexpected complexity of structure and function in parts of our environment hitherto regarded as homogeneous and simple. Others, like that of Professor Desch in chemistry or of Dr. Orr in agriculture, showed that knowledge advances not only by the fashionable and newest avenues. Others brought familiar theories to the test of new sets of facts. Others, again, appeared to have been written because it is the duty of a president to give an address. It was generally admitted that the individual papers presented to the sections described modest progress rather than dramatic developments. In short, the Southampton meeting was dull. But it does not follow that science is stagnating or that its annual meeting was unproductive. Before and behind every startling discovery there lie great fields of solid work, consolidation of what has been gained and preparation of what is to come, requiring a devotion of labor and knowledge out of all proportion to its immediate reward.

But the dullness of the Southampton meeting had other and less inevitable causes which did something to diminish local interest and to lessen the intrinsic benefits of the annual parliament of science. The organization has been allowed to become too complex. There were thirteen separate sections holding their meetings concurrently, as well as the additional subsection of forestry, a more or less permanent detachment from economy and engineering sitting on transport questions, and the conference of societies in correspondence with the British Association. By no fault of Southampton, which provided the accommodation accepted as sufficient by the officials of the association, these separate parts were placed at distances of which the extreme was nearly three miles. In most cities the visit of the British Association can not escape attention from the inhabitants. The pla-

cards indicating the buildings occupied, the special signposts in the streets, and the throngs of badged visitors hurrying from section to section compel attention and interest. In Southampton, even towards the end of the meeting, many members had failed to discover the remote or obscure position of some of the centers, and there is little doubt that many of the inhabitants were unaware that the association was holding its meeting in their town. The corporate feeling of the associates was greatly impaired, and there was much less than the usual opportunity for scientific men in different branches to come into contact. The discussions suffered from the same multiplication and the same disadvantages. There is a further and serious disadvantage, initially due to increasing subdivision, and accentuated at Southampton by its local geography; confusion arises in the public mind about the authority behind some of the pronouncements made. What is taken for the voice of corporate science in session may be little more than the vagaries of a group of specialists or even of faddists. If it be thought necessary to preserve the subdivisions, two steps might be taken. In the first place no invitation should be accepted unless it is certain that compact accommodation can and will be supplied; and, secondly, the number of papers should be reduced and their quality should be more seriously investigated beforehand. Such an arrangement would leave time for a limited number of carefully arranged discussions to which scientific men of several branches could contribute, and, if possible, for at least one or two great discussions in a central meeting-hall where the whole association would be assembled in plenary session.—*The Times*, London.

THE USE OF TEMPERATURE COEFFICIENTS IN THE INTERPRETATION OF BIOLOGICAL PROCESSES

THE measurement of temperature coefficients has found a wide vogue in biology, so much so that at least three books have been written on the subject, two of which do little more than summarize the extensive literature. In addition to these, ten years ago Arrhenius[1] published a short work in which he attempted to show the approximate correspondence of the temperature coefficients of living processes with those of chemical reactions. Doubtless Arrhenius did not expect his statements to be taken too seriously. He was content to show a general similarity in the temperature coefficients of chemical and biological processes. During the last year Crozier and his coworkers, as well as one or two other biologists, have enthusiastically taken up the subject and have sought to identify the temperature coefficients of living processes with those of specific chemical reactions.[2]

In general these authors have followed a principle first stated by Blackmann[3] and then developed by Pütter.[4] According to this principle, in any biological performance it is the slowest process of the entire group of processes that controls the speed of the ensemble. Crozier perhaps regards this as an obvious truth, for he makes no reference either to Blackmann or Pütter. In his investigations he seeks to identify the controlling process by comparing its temperature coefficient with the temperature coefficient of chemical reactions as they have been studied for the most part in test tubes.

On the face of it this is scarcely a sound procedure, for two reasons.

In the first place, the temperature coefficients of various reactions are usually known only in pure water. In protoplasm the speed of reaction and the temperature coefficient of the reaction would be modified by the viscosity of the protoplasmic medium. This point was recognized many years ago by Snyder,[5] who lists a number of references to show the effect of viscosity on reaction velocity and temperature coefficients. Other authors who may be consulted are Grummell[6] and Callow.[7]

Moreover, it is obvious that protoplasm is a heterogeneous system. It seems hardly safe to apply to such a system the data on the reaction velocity in homogeneous systems. It is true that for some reactions the reaction velocity for a heterogeneous medium is the same as it would be if the reaction were proceeding in a homogeneous medium. In other cases this is not true. Freundlich[8] distinguishes the two types of reactions and gives names to both. Fortunately Warburg[9] has discovered a method of determining which type of reaction is involved in any particular case. He has shown that at least some of the chemical reactions occurring in living cells are of the type in which the heterogeneity of the medium exerts an influence. The temperature coefficient of

[1] Arrhenius, 1915, "Quantitative Laws in Biological Chemistry," London.

[2] Crozier, 1924, *Jour. Gen. Physiol.*, VII, 123, 189, Proc. Nat. Acad. Sci., X, 461; Crozier and Frederighi, 1924, *Journ. Gen. Physiol.*, VII, 137, 151; Crozier and Stier, 1925, *ib.*, 429, 571; Glaser, 1924, *ib.*, 177; Cole, 1925, *ib.*, 581.

[3] Blackmann, 1905, "Annals of Botany," XIX, 281.

[4] Pütter, 1914, *Zeitsch. f. allgem. Physiol.*, XVI, 574.

[5] Snyder, 1911, *Amer. Jour. Physiol.*, XXVIII, 167.

[6] Grummell, 1911, *Jour. chim. phys.*, IX, 143.

[7] Callow, 1915, Trans. Far. Soc., XI, 55.

[8] Freundlich, Kapillarchemie, 3te Aufl., Leipzig 1923, pp. 187–204 and 305–315.

[9] Warburg, 1921, *Biochem. Zeitschr.*, CXIX, 134; see also Freundlich, *l.c.*

the reaction would then be influenced by conditions dependent on the heterogeneity of the medium. It is quite futile therefore to attempt to apply to these reactions the temperature coefficients determined for homogeneous systems or for systems of differing heterogeneity.

Nor is it by any means certain that the speed of biological processes is controlled by the speed of some one or more chemical reactions. In his attempt to answer the question Kanitz points out that a number of physical factors have exactly the temperature coefficient of chemical reactions. To the list cited by Kanitz[10] it may be well to add a process which is perhaps of great importance for biological activities. It has been shown that some coagulative processes have the temperature coefficient of a chemical reaction.[11]

The recent determination of the temperature curve of protoplasmic viscosity[12] may be of use in deciding the question as to whether the speed of living processes is controlled by chemical or physical forces. In some cells at least, as the temperature rises to 15° the viscosity increases. With further increase in temperature there is for a time a decrease in viscosity. If the speed of protoplasmic activity in general were controlled by one or more chemical reactions we would expect that the temperature coefficient of this reaction or reactions would be less below 15° than above 15°.[13] In many instances this is exactly the opposite of the truth. It has often been shown that the temperature coefficient of many biological processes is greater below 15° than above 15°. Kanitz[14] cites numerous cases, the phenomenon was emphasized by Mlle. Filon,[15] who quotes earlier references, and within the last year it has once more been elaborately emphasized by Crozier. But this argument does not settle the question. It could be supposed, as Pütter does, that as the temperature is raised, at some critical point a reaction with lower temperature coefficient may become the slowest reaction and take the place of the reaction with higher temperature coefficient which previously held this position. Such an explanation would not hold for those cases in which the temperature coefficient increases at a critical point. Cases of this sort apparently occur, as Pütter points out. But even so it might be possible to explain all types of cases on a purely chemical basis if we care to assume with Pütter that the speed of biological processes may to some extent be determined by chemical reactions which tend to retard the biological process.

It is rather astonishing to find Crozier[16] using the Blackmann-Pütter concept to explain cases in which as the temperature rises past a critical point, the controlling reaction is shifted from one with a relatively low temperature coefficient to one with a relatively high temperature coefficient. As the temperature rises we would have the reaction with relatively high temperature coefficient growing increasingly more rapid than the reaction with relatively low temperature coefficient. Crozier assumes that it may become slower. This is evidently a contradiction in terms. There are also other surprising deductions in Crozier's papers. Again and again he advances the hypothesis that oxidations and other biological processes are controlled by reactions in which H or OH ions are the sole catalysts. Such a hypothesis does not fit in very well with the prevailing notion that enzymes play at least some part in practically all biological reactions.

Finally it may be well to again sound the note of caution so frequently voiced by older students of temperature coefficients. The problem is far from simple, it is highly complex. The determination of the temperature coefficient of the entire ensemble of more or less unrelated chemical and physical phenomena involved in the movement of an ant or the duration of life of an insect larva, the comparison of this average temperature coefficient with the temperature coefficient of a single chemical reaction occurring in a totally different sort of a medium, may be interesting as a mathematical exercise, but it can hardly be assumed that any information so gained or that any immediate development of these widely-used methods of attack "may lead to an extremely important method of identifying reactions in undisturbed living matter."[17]

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[10] Kanitz, 1915, "Temperatur und Lebensvorgänge," Berlin.

[11] See Freundlich, *l.c.*, p. 640.

[12] Heilbrunn, 1924, *Amer. Jour. Physiol.*, LXVIII, 645.

[13] For as the temperature rises to 15° the viscosity increase would tend to slow the reaction and as the temperature rises above 15° the viscosity decrease would tend to hasten it. But it must be remembered that the viscosity changes in protoplasm may involve only the grosser elements and that such changes might have little effect on the velocity of chemical reactions.

[14] Kanitz, *l.c.*

[15] Filon, 1911, *Jour. de physiol. et de path. gen.*, XIII, 19.

[16] Crozier, *l.c.*

[17] Crozier, 1924, *Jour. Gen. Physiol.*, VII, 189.

SPECIAL ARTICLES

A NEW SOURCE OF POSITIVE IONS

IN researches with positive ions, considerable difficulty has been met in obtaining a satisfactory source of the required ions. Actually, there has been no source of positive ions which can compare to the present source of electrons in regard to constancy and ease of control.

Two sources of positive ions have been generally used to date: (1) The positive ions given off by heated metals, salts, or coated surfaces;[1] and (2) the positive ions or anode rays given off from a cold or hot anode, under electron or cathode ray bombardment.[2] In the case of the hot surfaces, the initial values of the positive emission were relatively high and decreased with time. The positive emission was a mixture of metallic ions and depended upon the presence of gas and previous gas treatment of the substance. In the anode rays, the variation in the discharge and temperature of the anode was always accompanied by a similar variation in the positive ion current, or anode rays.

In a thermionic investigation of the catalysts used for the synthesis of ammonia at the Fixed Nitrogen Research Laboratory, it was discovered that certain catalysts gave a copious and a very steady supply of positive ions. Positive ion currents as large as 10^{-4} amperes per square centimeter were observed. The emission was so constant at a given temperature that definite values of Richardson's work function could be obtained for these positive ions from the hot surface.

It has been found that either the catalyst granules themselves could be used as the hot anode, or the powdered catalysts could be coated on a platinum ribbon and used as the hot anode. The material consisted of a previously well fused mixture of iron oxide and about 1 per cent. of an oxide of an alkali or alkaline earth metal and in some cases also contained about 1 per cent. aluminum oxide. These mixtures are referred to as promoted catalyst. The iron is usually considered the catalyst proper and the other constituents are the promoters. The fusion had been carried out in a bed of the same material between water-cooled iron electrodes.[3] The mixture could be either partially reduced in an atmosphere of hydrogen at about 400° C. before being installed as the anode, or the unreduced material could be mounted as the anode and partially reduced in place. After a preliminary heat treatment which consisted of degassing and glowing the material, the positive ion current was very steady at a given temperature in a vacuum of 10^{-6} mm of Hg. By varying the temperature through several hundred degrees within the range of 400° to 1070° C., depending on the material studied, it was found that the positive current obeyed Richardson's equation $I_+ = AT^{1/2} \varepsilon^{\frac{-b}{T}}$ where $b = \frac{\varphi e}{k}$. Where I_+ is the saturation current, A and b constants of the equation, φ is the equivalent work function in volts, e the unit electric charge, k the Boltzmann gas constant, and T the absolute temperature. From this equation definite values of φ_+ for the positive ions were obtained from a fused mixture containing potassium.[4] From observations on the electron emission characteristics of a tungsten filament, placed so as to collect ionized vapor coming from the hot surface, it was concluded that the positive current consisted of positively charged atoms of potassium. Very recently, H. A. Barton at Princeton, through the courtesy of Professor K. T. Compton, tested this material in a mass spectrograph. The results showed very conclusively that the positively charged particles were singly charged atoms of potassium and that no other charged particles were emitted.

A sample from a thoroughly fused mixture of the oxides of iron, aluminum and caesium was also investigated and found to be a very suitable source of positively charged caesium ions. Other investigations on fusions of the oxides of iron, aluminum and an alkaline earth metal show that these mixtures also are good sources of positive ions. We believe the ions here observed are positive ions of the alkaline earth metal which had been introduced in the original mixture. It is hoped that the mass spectrograph results for these mixtures will show this as conclusively as they did in the case of potassium.

The lowest temperature at which the positive emission could be detected depended upon the mixture. This temperature was the lowest for mixtures containing caesium and the highest for mixtures containing an alkaline earth metal.

There now exists therefore a source of positive ions of the alkali metals and no doubt alkaline earth metals which compare in constancy, ease of operation and control, with the present thermionic sources of electrons.

A new field of research should be opened up by this high vacuum source of positive ions. Experiments on ionization effects in gases and on surfaces with this source of positive ions, together with the possible influence of the positive emission from the catalyst surface on catalytic activity, are under investigation.

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JUNE 11, 1925

[1] O. W. Richardson, "Emission of Electricity from Hot Bodies," 2nd ed., chap. 6–8.

[2] Dempster, *Phys. Rev.*, 11, 316 (1918); 18, 415 (1921); Aston, *Phil. Mag.*, 42, 436 (1921).

[3] Method of preparation to be described by Larson and Richardson in the *Journal of Industrial and Engineering Chemistry*.

[4] Kunsman, *Phys. Rev.*, 25, 892, June, 1925.